COASTAL MIXING AND OPTICS MOORED ARRAY

Steven J. Lentz
Woods Hole Oceanographic Institution
Department of Physical Oceanography
Woods Hole, MA 02543
Tel: 508-289-2808 Fax: 508-457-2181 e-mail: slentz@whoi.edu

Albert J. Plueddemann
Woods Hole Oceanographic Institution
Department of Physical Oceanography
Woods Hole, MA 02543
Tel: 508-289-2789 Fax: 508-457-2181 e-mail: aplueddemann@whoi.edu

Steven P. Anderson
Woods Hole Oceanographic Institution
Department of Physical Oceanography
Woods Hole, MA 02543
Tel: 508-289-2876 Fax: 508-457-2181 e-mail: sanderson@whoi.edu

Award #: N00014-95-1-0339

LONG-TERM GOALS

Our long-term goal is to identify and understand the dominant vertical mixing processes influencing the evolution of the stratification over continental shelves.

OBJECTIVES

We want to understand the dynamics of the surface and bottom boundary layers over continental shelves and how the boundary layers contribute to mixing and the evolution of the stratification. We are particularly interested in the relative contributions of local, one-dimensional mixing processes, such as wind forced mixing, cooling, and tidal mixing versus three dimensional advective effects.

APPROACH

An array of moorings were deployed at a mid-shelf location in the Mid-Atlantic Bight in August 1996 and recovered in June 1997 to span the destruction of the thermal stratification in fall and redevelopment of the stratification in spring. The moored array consisted of a heavily instrumented central site (70-m isobath) and three more lightly instrumented surrounding sites: about 10 km onshore (64-m isobath), about 12 km offshore (86-m isobath) and 15 km along isobath toward the east. At each site currents, temperature and conductivity measurements spanned the water column. Additionally, the central site included meteorological measurements to estimate wind stress, surface heat

flux and surface buoyancy flux, wave measurements, and a fanbeam acoustic doppler current profiler (ADCP) to identify Langmuir circulation.

WORK COMPLETED

The moored array and all of the instrumentation were successfully recovered in June from R/V *Oceanus*. A cross-shelf conductivity-temperature-depth (CTD) section occupied during the deployment cruise was repeated during recovery operations. The substantial post-calibration and data processing task associated with over 80 instruments began immediately after recovery and is ongoing. Data return appears to be excellent.

Surface analysis and flux fields from regional Numerical Weather Prediction models were archived during the field observation period. We now have an archive of Eta and Rapid Update Cycle (RUC) model surface fields for the eastern seaboard available on CD-ROM and have completed initial intercomparisons with our observations.

A newly developed fanbeam ADCP was successfully operated from a subsurface mooring at the central site, providing horizontal profiles of surface velocity convergence associated with Langmuir circulation. To our knowledge this represents the first long-term (6 months) record of Langmuir circulation variability in conjunction with the relevant surface forcing.

The sonic anemometer system on the central mooring ran continuously during the entire deployment. This data has been successfully merged with the vector-averaging wind recorder (VAWR) data.

RESULTS

A number of intriguing features were evident from preliminary evaluation of the data. The August 1996-June 1997 deployment captured both the breakdown in fall and development in spring of the stratification. Thermal stratification was strong in August with near surface temperatures of 18-20°C and near-bottom temperatures of 8°C. The thermal stratification decreased in four abrupt steps from September through mid November associated with several storm events and westward (downwelling) alongshore currents. Regional gridded meteorology products from numerical weather prediction (NWP) models indicated that the major storm events (including a hurricane, several northeasters and a mid-latitude cyclone) had a different spatial and temporal character in its forcing of the ocean. Thermal stratification at the central site was weak from mid November through mid December due to strong winds and surface cooling. The water column restratified in mid December due to an intrusion of warm (up to 10°C), salty, slope water along the bottom, under the cold (4-6°C), fresh, shelf water. This intrusion, which was presumably an onshore displacement of the shelf-slope front, was about 20 m thick and persisted from mid December through March. Historical data from the Nantucket Lightship suggests this persistent onshore displacement of the shelf-slope front is anomalous. Thermal

stratification began to redevelop in late April due to surface heating and increased steadily through early June.

The comparison between the sonic anemometer and VAWR data revealed extremely good agreement between the two sensors. The excellent agreement between the two systems includes the strong wind events, which indicates that the two sensor systems worked well under these adverse conditions. Besides the hurricane, the systems captured a northeastern that imparted two short-lived but intense events separated by short quiescent period as the weather system moved through the mooring site in early December. This event will be investigated in conjunction with the bottom boundary layer measurements of Trowbridge and Williams.

IMPACT/APPLICATION

The successful field effort has yielded the most comprehensive set of moored array data on the New England shelf for studying vertical mixing and more generally the shelf dynamics. It should provide a critical context for interpreting other measurements acquired during the Coastal Mixing and Optics field program.

TRANSITIONS

none

RELATED PROJECTS

We anticipate collaborations with many of the other PIs in CMO.

We have already provided data to Dickey to aid in interpretation of his moored optics measurements and plan to provide the moored tidal data to aid in detiding the shipboard ADCP data.

Bottom boundary layers - We have already exchanged some data with Trowbridge and Williams and plan to collaborate closely with them and Paul Hill in understanding the dynamics of the bottom boundary layer and its impact on the rest of the water column.

Optics - We have begun some preliminary collaboration with Dickey and others in their initial look at the influence of Hurricanes on the optical properties of the water and have provided them with some of our data to aid in the interpretation of their measurements.

Spatial variability - We anticipate collaborating with Barth and Kosro and with Gawarkiewicz and Pickart (Primer study) to determine the influence of spatial variability in our interpretation of the moored observations. As a first step we will provide the moored current and pressure data to aid in detiding the shipboard ADCP data.

Hurricane response - We plan to collaborate with the GLOBEC PIs (Irish, Brink, Beardsley) on an examination of the response to Hurricane Edouard over the New England shelf and Georges Bank.

National Weather Prediction model validation: We have been exchanging results from our NWP validation effort with Stan Benjamin, NOAA/ERL Forecast Systems Laboratory, who is developing the RUC regional weather forecasting model for National Centers for Environmental Prediction (NCEP).

The high frequency data from the sonic anemometer are now being analyzed and are being used to compute the fluxes using the inertial-dissipation (ID) method. Recent work from ONR's Marine Boundary Layer's program has provided evidence that the ID method is very sensitive to wave-induced effects. Simple models are now being developed to account for these effects and provide additional insights into the exchange of energy between the wind, waves, and currents. We will continue to collaborate with the MBL PIs (Friehe, Farmer, Smith, Pinkel) in our efforts to incorporate wave-induced forcing in our modeling efforts.

REFERENCES

Baumgartner, M. F., and S. P. Anderson, 1997. Acquisition, description and evaluation of atmospheric model products for the Coastal Mixing and Optics Experiment. WHOI, Technical Report, UOP-97-1, WHOI-97-02, 186 pp.

Galbraith, N., W. Ostrom, B. Way, S. Lentz, S. Anderson, M. Baumgartner, A. Plueddemann and J. Edson, 1997. Coastal Mixing and Optics Experiment. Mooring Deployment Cruise Report R/V *Oceanus* Cruise Number 284, 31 July-11 August 1996. WHOI, Technical Report, UOP-97-02, WHOI-97-13, 92 pp.